

CLAIMS

1. Method for detecting unbalanced conditions of a rotating load driven by a synchronous electric motor (3) in washing machines (1) and similar household appliances including a rotably drum (2) and wherein at least a transient step is provided with angular speed (ω) variation of the rotably drum (2), characterised by the following steps:

- constantly monitoring and detecting the instantaneous current (I_q) absorbed by the motor;

- calculating in real time the value of an unbalanced mass (m) on the basis of the variation (Δ) of said current (I_q) and starting from a predetermined reference obtained by experimental results and by applying a calculation formula representative of the kind of load imbalance;

- current driving said motor (3) according to said value of unbalanced mass (m) adjusting the angular revolution speed of the motor.

2. Method according to claim 1, characterised in that it provides a comparison between the standard deviation (σ) of said current (I_q) with a predetermined reference stored in a memory unit including for example an average value of this current (I_q) or a predetermined threshold value.

3. Method according to claim 1, characterised in that the imbalance signal is computed as a difference between the last sampled value of the current signal (I_q), in the time instant wherein the absolute value of the first derivate of said current signal (I_q) is minor than a predetermined threshold and the second derivate of the same signal I_q is positive, and the last sampled value of said current signal (I_q) in the time instant wherein the absolute value of the first derivate of said current signal (I_q) is minor than a predetermined threshold and the second derivate of the same signal I_q is negative

4. Method according to claim 1, characterised in that the measure of said unbalanced mass (m) occurs at first by measuring said current (I_q) variation (Δ) with a low number of drum revolutions.

5. Method according to claim 4, characterised in that said low number of revolutions is comprised between 60 and 80 revolutions per minute.

6. Method according to claim 4, characterised in that it provides a step for controlling that the measured variation ($\Delta(I_{q1})$) at a low number of revolutions is lower than a predetermined acceptable reference value ($\Delta(I_{q1})_{AMM}$) and a subsequent order of slowing down the drum rotation speed (w) if this check gives a negative result.

7. Method according to claim 4, characterised in that it provides a step for controlling that the measured variation ($\Delta(I_{q1})$) at a low number of revolutions is lower than a predetermined acceptable reference value and a subsequent order of gradually increasing the drum revolving speed (w) if the control gives a positive result.

8. Method according to claim 7, characterised in that the gradual speed increase continues until about 150 revolutions per minute are reached.

9. Method according to claim 7, characterised in that it provides a step of further controlling that the measured variation ($\Delta(I_{q2})$) at increased number of revolutions is lower than a second predetermined acceptable reference value ($\Delta(I_{q2})_{AMM}$).

10. Method according to claim 9, characterised in that it provides a centrifugal step at reduced rotation speed if said further control gives a negative result.

11. Method according to claim 9, characterised in that it provides that a centrifugal step is started if said further control gives a positive result.

12. Method according to claim 9, characterised in that it provides a slow down, without stop, of the drum (2) rotation speed in order to

cause a new load distribution if said further control gives a positive result.

5 13. Method according to claim 10, characterised in that it provides a steady monitoring of said measured variation ($\Delta(Iq_2)$) in the centrifugal step at reduced speed.

14. Method according to claim 2, characterised in that the comparison between the variation (Δ) and said current (Iq) occurs both in static unbalanced conditions and in dynamic unbalanced conditions.

10 15. Method according to claim 14, characterised in that the one variation operator is the standard deviation operator (σ) and is drawn, for a dynamic imbalance, from the following relation:

$$\sigma(Iq)_{\text{dynamic}} = m * K2 * w^{\alpha} + Ko$$

Where: Ko , $K2$ and α are known constant experimentally-determined values, w is the rotation speed and m is said unbalanced mass.

AMENDED CLAIMS

[received by the International Bureau on 13 December 2004 (13.12.04);
original claim 1 amended; remaining claims unchanged (3 pages)]

CLAIMS

1. Method for detecting unbalanced conditions of a rotating load driven by a synchronous electric motor (3) in washing machines (1) and similar household appliances including a rotably drum (2) and wherein at least a transient step is provided with angular speed (ω) variation of the rotably drum (2), characterised by the following steps:

- constantly monitoring and detecting the instantaneous current (I_q) absorbed by the motor;
- calculating in real time the value of an unbalanced mass (m) on the basis of the variation (Δ) of said current (I_q) and starting from a predetermined reference obtained by experimental results and by applying a calculation formula representative of the kind of load imbalance;
- said current (I_q) driving as a feedback signal said motor (3) according to said value of unbalanced mass (m) adjusting the angular revolution speed of the motor in real or continuous time.

2. Method according to claim 1, characterised in that it provides a comparison between the standard deviation (σ) of said current (I_q) with a predetermined reference stored in a memory unit including for example an average value of this current (I_q) or a predetermined threshold value.

3. Method according to claim 1, characterised in that the imbalance signal is computed as a difference between the last sampled value of the current signal (I_q), in the time instant wherein the absolute value of the first derivate of said current signal (I_q) is minor than a predetermined threshold and the second derivate of the same signal I_q is positive, and the last sampled value of said current signal (I_q) in the time instant wherein the absolute value of the first derivate of said current signal (I_q) is minor than a predetermined threshold and the second derivate of the same signal I_q is negative

4. Method according to claim 1, characterised in that the measure of said unbalanced mass (m) occurs at first by measuring said current (I_q) variation (Δ) with a low number of drum revolutions.

5. Method according to claim 4, characterised in that said low number of revolutions is comprised between 60 and 80 revolutions per minute.

6. Method according to claim 4, characterised in that it provides a step for controlling that the measured variation ($\Delta(I_{q1})$) at a low number of revolutions is lower than a predetermined acceptable reference value ($\Delta(I_{q1})_{AMM}$) and a subsequent order of slowing down the drum rotation speed (w) if this check gives a negative result.

7. Method according to claim 4, characterised in that it provides a step for controlling that the measured variation ($\Delta(I_{q1})$) at a low number of revolutions is lower than a predetermined acceptable reference value and a subsequent order of gradually increasing the drum revolving speed (w) if the control gives a positive result.

8. Method according to claim 7, characterised in that the gradual speed increase continues until about 150 revolutions per minute are reached.

9. Method according to claim 7, characterised in that it provides a step of further controlling that the measured variation ($\Delta(I_{q2})$) at increased number of revolutions is lower than a second predetermined acceptable reference value ($\Delta(I_{q2})_{AMM}$).

10. Method according to claim 9, characterised in that it provides a centrifugal step at reduced rotation speed if said further control gives a negative result.

11. Method according to claim 9, characterised in that it provides that a centrifugal step is started if said further control gives a positive result.

12. Method according to claim 9, characterised in that it provides a slow down, without stop, of the drum (2) rotation speed in order to

cause a new load distribution if said further control gives a positive result.

13. Method according to claim 10, characterised in that it provides a steady monitoring of said measured variation ($\Delta(Iq_2)$) in the centrifugal step at reduced speed.

14. Method according to claim 2, characterised in that the comparison between the variation (Δ) and said current (Iq) occurs both in static unbalanced conditions and in dynamic unbalanced conditions.

15. Method according to claim 14, characterised in that the one variation operator is the standard deviation operator (σ) and is drawn, for a dynamic imbalance, from the following relation:

$$\sigma(Iq)_{\text{dynamic}} = m * K2 * w^{\alpha} + Ko$$

Where: Ko , $K2$ and α are known constant experimentally-determined values, w is the rotation speed and m is said unbalanced mass.